5 (Previously presented) A method according to claim 2 wherein the current-conducting holder is made from aluminum wire.

REMARKS

The Official Action of June 22nd, 2011 has been carefully considered and reconsideration of the application as amended is respectfully requested.

Claim Rejections - 35 USC 112

The Examiner has rejected claims 2-5 as being indefinite. In response the claims have been amended such that the part is made of a valve metal or valve metal alloy and such that working voltage to said part is passed through the electrolyte. Consequently Applicants submit that the claims as amended meet the requirements of 35 USC 112 second paragraph.

Rejection in view of McNeill et al.

The Examiner submits that claims 2, 3 and 5 are anticipated by *McNeill et al.*, (U.S. Pat. No. 3,293,158). Applicants respectfully traverse this rejection.

The claimed invention is directed to a method of producing a heavy protective coating on a part made from a valve metal or valve metal alloy involving micro-arc oxidation. The method involves placing the part in an electrolyte on a current-conducting holder which is connected to a terminal of a power supply and producing a working voltage through the electrolyte to the part. The voltage is then increased until a micro-arc discharge is originated on the surface of the part and a protective coating is formed

thereon. Finally the current-conducting holder is provided with a coating of an electroinsulating material only at the air-electrolyte interface which ensures that as the voltage is increased current reduction to the part is avoided.

The Examiner submits that *McNeill et al* discloses an anodic spark reaction process which is equivalent to a micro-arc discharge. Furthermore the Examiner argues anodes in the form of cylindrical rods which are mounted in tight-fitting Teflon sleeves are equivalent to a current-conducting holder which is connected to a terminal of a power supply and which has a coating of an electroinsulating material thereon only at the air electrolyte interface.

In response Applicants submit that the anodic spark reaction process of *McNeill et al* does not provide a disclosure of micro-arc discharge.

Furthermore there is no disclosure in *McNeill et al* of a separate current-conducting holder.

Finally Applicants submit that the Telfon sleeves of *McNeill et al* do not provide a disclosure of a selective coating of electroinsulating material at the air-electrolyte interface that can prevent current reduction to the part as the voltage is increased.

McNeill et al discloses the technology of coating parts by anodic spark deposition, whereas the present invention relates to the technology of micro-arc oxidation. Both methods are used to produce solid coatings on parts made of valve metals or valve metal alloys.

However anodic spark deposition is a process which applies ceramic coatings to metal surfaces by dielectric breakdown on the surface of a metal anode immersed in an electrolyte bath. This dielectric breakdown relates to a thin oxide barrier layer on the metal surface, which is typically the result of conventional anodization. The breakdown of this

barrier layer during the deposition is accompanied by sparking, hence the name of the anodic spark deposition.

The spark deposition requires at least one metal anion in the electrolyte which is deposited by this process. Generally the anodic spark deposition process involves forming oxide coatings,during the dielectric breakdown, from non-metallic ions of the electrolyte wherein at the end of the process the electrolyte contains only the metal ions from the anode (see for example RU 2070622). Anodic spark technology is the result of the development of traditional anodizing and can only provide a solid coating having a thickness that is not above 100 microns.

At various voltages qualitative changes in the process can occur. These may include a sharp increase in the electronic component of the current flowing through the interface between the electrolyte-oxide and oxide-metal and the appearance of numerous electrical breakdowns of the film. This leads to a significant rise in temperature in the channels of a breakdown and in the surrounding areas, thereby the growth of coatings is greatly accelerated. At the same time in the breakdown channels a low-temperature plasma is formed in which reactions take place leading to incorporation of electrolyte components into the oxide. Thus, the consequence of the breakdown at high field intensity is, on the one hand, the acceleration of the oxide formation, and on the other hand, the change of the physical and chemical properties of the coating. Analysis of the anode spark coatings shows that they, along with oxides of the metal substrate, contain large amounts of atoms or groups of atoms of the electrolyte. The introduction of electrolyte ions is determined by the nature of the electrolyte, and it is also due to the mechanism of formation and numerous anodic processes (electrochemical and chemical processes, adsorption, ion exchange processes, etc.) that occur at the film surface, in the pores and in the volume of

the oxide. The contribution of each of these processes depends on the conditions of formation and concentration of the electrolyte (see "Structure and Composition of Anodic-spark Coatings on Valve Metals" by V.F. Borbat, et al).

Contrary to anodic spark deposition micro-arc oxidation (MAO) is a method which forms multifunctional ceramic-like protective layers on the surface and near-surface zones of parts made of valve metals and valve metal alloys. The method is based on the use of surface energy deriving from electric discharges in an electrolyte.

The main feature of MAO is that when high voltage is applied between the part and the electrode migrating points of micro-arc discharges appear on the surface of the part. Under thermal, plasma-chemical and hydrodynamic effects the surface layer of the part is converted such that a ceramic coating which has a strong adhesion to the metal base is provided.

Unlike the traditional anodizing process, this process is conducted so that it corresponds to the conditions of microplasma processes on the treated surface. Transition to the stage of micro-arc discharges alters the mechanism of deposition of the oxide coatings which provides a coating of better quality compared to those provided by traditional electrolysis. The electrical mode of treating, the composition of the electrolyte and the nature of the material have a decisive effect on the phase composition and structure of the surface layers in MAO. These parameters must be properly selected for achieving the desired result which is the formation of a solid coating.

A distinctive feature of the method is constricting (localization by pinching) a micro-arc discharge in micro-and nano-pores of the initial barrier layer. As a result, there is short ($\sim 10^{-6}$ s) local heating of the breakdown area to a temperature of $\sim 10^{4}$ °K, and subsequent high-speed cooling after the extinction of the discharge. This creates the conditions for the

occurrence of plasma-chemical reactions in the metal-oxide-electrolyte system and quenching of the resulting products. The result is a synthesis of nanoscale oxide-ceramic structural components, which form the basis for further processing of the composite layer tightly coupled to the base metal.

The coating is formed due to the contribution of two processes: ionic conductivity characteristic of traditional anodizing and transport of particles through the channels of breakdown (micro-arc synthesis).

The method of micro-arc oxidation was developed in 1969, while *McNeill et al* was issued in 1966, i.e. MAO is a next-generation technology in relation to the process of spark anodizing.

Furthermore *McNeill et al* teaches that the anode has a shape of a cylindrical rod fitted with a Teflon sleeve that covers the surface of the anode at the electrolyte - air level.

Contrary to *McNeill et al* in the claimed invention the anode is connected to a separate holder made, for example, of a metal wire. The holder holds the part. At the level of the electrolyte - air the holder surface is covered with an insulating material.

Consequently it should be noted that no holder is mentioned in *McNeill et al* wherein a Teflon bushing is directly attached to the electrode, i.e. a portion of the electrode is isolated. This prevents unwanted stray currents only in the area between the electrolyte and air.

In the claimed invention it is essential that the part holder is coated from outside with an electrical insulating material at the air – electrolyte boundary. This arrangement makes it possible to avoid influence of the gas-vapor mixture, i.e. to avoid shunting of the part and decreasing current through it. Furthermore it creates conditions for further increase of

the voltage and thus provides further rapid growth in the thickness of the protective coating.

At a particular point the number of micro-arc discharges on the surface of the part decreases sharply up to complete disappearance, and the voltage continues to rise. In the latter case (complete disappearance) at first the voltage even slightly reduces, but then begins to rise. Observation of the treated part surface at this point shows that on the surface of the part there is plurality of molten microsections through which the current flows. This indicates that the MAO is not completed, but at the same time a new physical process occurs. This process is possible only when there is no electrolyte-air boundary, and disappearance of the boundary is due to the insulation of the holder.

Contrary to the present invention placing an electrode in a Teflon sleeve provides no such advantage and this merely shifts the electrolyte – air boundary to the place where the Teflon sleeve ends wherein destruction will result .

Consequently if a Teflon sleeve was employed a poor quality porous coating would begin to form on the surface of the holder not immersed in the electrolyte at the air-electrolyte boundary due to the presence in the air of electrolyte vapors as well as surface bursting gas bubbles (characteristic of MAO), which in contact with discharges on the holder burst. If this process is not stopped, porous outgrowths will occur and the holder will be destroyed. Due to the presence of insulation on the electrolyte - air boundary it becomes possible to avoid the formation of porous outgrowths preventing the destruction of the holder.

Therefore in summary the claimed invention differs from that of *McNeill et al* in that:

1. They use different processes: anodic spark deposition as opposed to micro-arc oxidation;

2. In *McNeill et al* the electrode has a sleeve of Teflon at the electrolyte-air boundary, whereas the claimed invention provides a separate holder, and the holder is coated with an insulating material on the electrolyte-air boundary;

3. The Teflon sleeve on the electrode of *McNeill et al* is designed to reduce stray currents, but is still very vulnerable to destruction, whereas in the claimed invention the insulating coating allows for increasing the voltage and thereby increasing the coating thickness and its strength, and in addition, prevents the destruction of the holder.

As a result, the claimed invention provides a thick and durable coating compared to the coating disclosed in *McNeill et al* .

Finally it should be noted that whilst the steps for implementing the claimed invention and those of *McNeill et al* are similar to all electrochemical methods *McNeill et al* is directed to anodic spark deposition whereas in the claimed invention the process employs micro-arc oxidation wherein mode, composition of electrolyte, voltage, and other important parameters are selected for this process. The MAO method in conjunction with the presence of insulation on the holder at the electrolyte-air boundary provides for solid coatings with greater thickness and adhesion comparable to the strength of the material of the workpiece, which cannot be obtained by anodic spark deposition.

Consequently Applicants submit that the cited reference does not show all features of the invention defined by the claims and thus the claims are not anticipated by *McNeil et al.*

Rejection in view of Patel et al.

The Examiner submits that claims are anticipated by *Patel et al.*, (U.S. Pat. No. 6,197,178). Applicants respectfully traverse this rejection.

Contrary to the present invention *Patel et al* is directed to the technology of coating parts by micro-arc oxidation wherein the workpieces are arranged on the electrode, which has insulation coating over its entire length whereas in the claimed invention a part is attached to a holder having an insulating coating only at the electrolyte – air boundary.

The function of the electrode coating with an insulating material, as described in *Patel et al* is to protect it from the external environment. However during the process described in *Patel et al* in some local areas the insulating material can reach a temperature which exceeds 1000°C which results in the thermal destruction of the insulating material.

Furthermore there is a strong mechanical effect of local hydroblows from microdischarges, which leads to peeling of adhesives and sealants from the metal holder. In addition, electrocapillary phenomena occur because of the large value of the applied voltage. As a result, the electrolyte can leak under the insulation layer electrochemically and thermally destroying the surface of the metal electrode and the insulator. Therefore, such coating is unstable.

Contrary to *Patel et al* in the claimed invention any coating along the length of the holder is negligible, hence the power of any discharges is lower. Electrolyte leakage may occur, but it does not lead to the destruction of the holder, since neither common anodizing nor initial MAO can destroy the holder.

The function of the local coating in the claimed invention is to provide increased voltage on a part in order to obtain a thick-walled hard coating and to prevent the destruction of the holder, as described above.

Thus, the insulating coating of the claimed invention provides for the growth of the thickness and hardness of the coating and secures the integrity of the holder, whereas *Patel et al* provides insulation of an electrode from corrosive medium, i.e. it is employed for a different function.

Therefore Applicants submit that *Patel et al* do not provide any specific disclosure of a method that involves the use of a current-conducting holder that has been selectively coated with a electroinsulating material at the air-electrolyte interface portion given that the electrodes of *Patel et al* have an insulted exterior over their entire surface.

Consequently Applicants submit that the cited reference does not show all features of the invention defined by the claims and thus the claims are not anticipated by *Patel et al.*

In view of the foregoing, it is respectfully submitted that all rejections and objections of record have been overcome and that this application is now in order for allowance. An early notice of allowance is earnestly solicited and is believed to be fully warranted.

Respectfully submitted,

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